92-07071/

C-CORE

REPORT OF ACTIVITIES

1987 - 1988

Centre for Cold Ocean Resources Engineering
Memorial University of Newfoundland
St.John's, NF, A1B 3X5, Canada
Tel (709) 737-8354 Fax 709 -737-4706

Report of the Director and the Board of Governors

1987-1988

During this year, C-CORE has gone through a very encouraging period. The Centre's staff have found themselves in a stimulating and exciting environment. Research programs have shown positive growth, productivity has increased and a record amount of contract research has been achieved. C-CORE has been placed in an excellent position to maximize the return on private sector investment in the research programs.

The announcement in March 1987 that C-CORE was being awarded $5 million from the Offshore Development Fund (ODF) over the next five years put the Centre in a unique position to lever funds from other sources. Over the five years of the ODF award, the Centre must find matching funds of 2.25 dollars for every one dollar that it can draw from the fund. Each year, the Centre must achieve a financial target to draw on the monies in the fund allocated for that year. Although certain types of income to C-CORE are excluded from the matching fund formula, C-CORE achieved its financial target in the first six months of the 1987/88 fiscal year.

A major revision of the five research plan was undertaken during the year. C-CORE's first five year research plan was implemented in 1985 but in 1986, cutbacks were made to the research programs in response to the economic situation in the industry. The encouraging growth in support from industry and government in 1987 necessitated a substantial revision to the plan. At a research planning workshop in May 1987, operational scenarios were developed and technical issues and opportunities were identified. From these discussions, recommendations were made by the Associates and other experts on research programs appropriate to the Centre's expertise. A revised five year plan for 1987-1991 was proposed in which three major research thrusts were retained from the original plan but significant modifications were made to the major program areas within each thrust. The revised five research plan (included with this report) was endorsed by the Board of Governors at its 1987 fall meeting.

Subsequently, a five year financial plan for the period, 1987-1991, was developed to support the research plan. It is estimated that $18.25 million is required by the Centre for the research programs from 1987 to 1991. Financial targets were established for the research groups to achieve in contract funding from industry and government. These financial targets included grants from the Natural Sciences and Engineering Research Council (NSERC). The five year staffing requirement for the research plan was also determined. The Centre began actively searching for staff and by the end of the year, we had nearly reached our targeted level. On a number of occasions, we were able to attract qualified Newfoundlanders who were working in other locations across Canada to come back to the province.

Over the last three years, contract funding for the Centre's research

activities has been growing steadily. This year, C-CORE achieved over $1.2 million, a record amount for the Centre. We expect this trend to continue as the senior research staff establish their track records and attract substantial project funding. Productivity in terms of papers published in refereed journals, as conference papers and contract reports has already exceeded previous years. The type of international peer review of C-CORE research work that occurs with refereed publications is very important in ensuring quality of the Centre's research programs.

The Centre has also been very active in the transfer to technology to the private sector. Research on the technology to design and build a shore-based ground wave radar system which can detect targets over-the-horizon was completed in 1987 by the Centre in cooperation with the Faculty of Engineering and Applied Science, Memorial University. A company, Northern Radar Systems Limited (NRSL), has been established with a private sector group to exploit the technology. Phase I of the project, to design a shore-based ground wave radar system, has been completed. Funding is now being secured for Phase II which will see the construction of a full scale prototype system at Cape Race, Newfoundland. Seabright Corporation Limited, a wholly-owned company of Memorial University, holds the shares in NRSL on behalf of C-CORE. The Centre will be involved in the technical aspects of Phase II of the NRSL project.

Confidence and support by our Associates in industry and government and by the Board of Governors will continue to be an intergral part of the success of C-CORE's operation. We have already received substantial support, both financial and support-in-kind, from industry and government during this year. The Centre was able to maximize investments in our research programs through a number of university / industry programs. In the upcoming year, we expect our level of co-operative programs with other groups to increase. Planning has already begun for involvement in co-operative field experiments with industry and government. Further opportunities to transfer technology to the private sector will be explored. Projections for 1988 - 1989 indicate that it will be a year of increased opportunities for C-CORE. The Centre is well placed to initiate new programs and take advantage of these opportunities. We look forward to responding to new challenges in the upcoming year.

J.I. Clark
Director of C-CORE

G.C. Eaton
Chairman of the Board of Governors

PROGRAM REPORTS

ICE ENGINEERING

Ice research at C-CORE has always been closely linked to industry's offshore activities in the Beaufort Sea and on the east coast. As Canada moves closer to offshore oil development in these areas, C-CORE's ice research plan has been revised to increase the emphasis on the engineering aspects of ice.

Mechanical Properties

Indentation Testing: Data sets collected on the Resolute field experiment in April 1987 were analysed and thin sections were prepared from the ice blocks to investigate the recrystallization processes experienced during the indentation test. The 1988/89 experiment was conducted at Resolute Bay during April. The program used two different types of indentors (spherical and flat) to collect data on the mechanisms associated with indentation of ice. The Institute for Marine Dynamics, National Research Council Canada and the Polar Continental Shelf Project provided financial and logistic support to the project.

Gulf Canada Resources: A two month contract for Gulf Canada Resources on the dynamic analysis of the Molikpaq was completed and submitted. This report is an analysis of time series of seven "ice events" during which the structure experienced major vibrations.

Canada-France Cooperation: Dr. Nadreau visited the Laboratorie de Glaciologie et de Géophysique de l'Environnement (LGGE-Grenoble) as part of the Canada-France scientific program on ice indentation at high strain rates. Dr. Jacques Meysonnier from LGGE spent one year at C-CORE.

Strainmeter Performance: The analysis of strainmeter data collected on the 1987 field program to the Kaubvik Caisson Retained Island, Beaufort Sea, was completed. The program was supported through an NSERC Cooperative R&D grant to Dr. I. Jordaan, Faculty of Engineering & Applied Science. Esso Resources Canada Ltd. was the industrial partner.

Spray Ice: C-CORE undertook field experiments in December and in February to collect and analyse data from a Beaufort Sea site on behalf of Esso Resources Canada. The purpose of this project was to document the salinity, temperature and current of the water column at three different potential sites for spray ice islands. Ms. Abigail Steel, a graduate student, was involved in building a spray ice island in the Esso laboratory in Calgary. She undertook an analysis of the ice samples from the test structure.

Ice Dynamics

Wave Interaction with Pack Ice: Motion data collected on the pack ice

during the Labrador Ice Margin Experiment (LIMEX) of March 1987 were analysed. A final report was submitted to MacLaren Plansearch; the data were used to verify a wave/ice interaction model developed for the Grand Banks.

Wave-Induced Iceberg Motion Study (WIIMS): A final report was submitted to NSERC describing the research conducted over the past 3 years to obtain field measurements of the motion of bergy bits and growlers in waves. All data sets (23 in total) were processed to yield instantaneous iceberg motions. Transformations of these motions to the iceberg centres-of-gravity were performed.

Dynamics of Iceberg Grounding and Scouring (DIGS): A Report describing the 1985 DIGS field experiment and the subsequent data analysis and interpretation was submitted to the Environmental Studies Research Fund (ESRF). A number of other scientific publications arising from this program have been published.

A DSS contract was awarded to sponsor the further development of a classification scheme for iceberg scour effects based on iceberg stability characteristics. This work will help to guide the development of more ambitious iceberg scour models.

Search Radar Evaluation: A report was submitted to ESRF describing the performance of two Litton Industries search radars employed for operational iceberg detection during 1986 and 1987.

Ice/Structure Interaction

Full Scale Iceberg Impact: A detailed feasibility study was started to define the requirements for a full scale iceberg impact experiment. A suitable site near St. Anthony was identified. Simple model testing in a test flume was undertaken to demonstrate the pendulum/winching system. Phase I was completed by March 31.

REMOTE SENSING

The Remote Sensing Group focused on the development of Ground Wave Radar technology for applications in the ocean environment. There were three major research activities.

Fundamental Research in electromagnetic propagation and scatter, and in signal processing and data analysis.

Target Detection using Ground Wave radars to detect sea ice, icebergs, vessels and low elevated targets.

Environmental Measurements using Ground Wave radars to measure ocean surface currents and sea states.

Several projects within these areas reached a mature stage. Commercial exploitation of the technology was planned and actively pursued by the Centre in its five year research plan.

Fundamental Research

The fundamental research program encompassed analytical modelling and simulation with particular emphasis on Ground Wave Radar techniques. Analytical expressions for the radar cross-section of metallic targets (including vessels and elevated targets) were developed and software was written to implement these expressions. In addition the models for the ocean clutter return were enhanced through the development of offpatch scatter models. These models expand the suite of modelling software and enhance our ability to evaluate and simulate the proposed Ground Wave Radars. The Department of National Defence sponsored these projects through a series of contracts to evaluate Ground Wave Radars for defence applications.

Target Detection

Ice Hazard Detection: The ice hazard detection program was endorsed in 1987 with the award of an NSERC co-operative research and development grant. The overall aim of the program is to develop engineering specifications for a rig-mounted Ground Wave ice hazard detection radar; the program will continue for a further two years. The partners in this program are Mobil Oil Canada Ltd., Husky Bow Valley East Coast project and Northern Radar Systems Ltd. (NRSL). A set of data collection experiments were conducted aboard the BowDrill 3 to evaluate two factors: the effects of the additional clutter present when the radar is surrounded by ocean and the effects of platform motion contaminating the radar data. Research on techniques for processing the rig data is progressing; techniques for eliminating and mitigating the effects of platform motion are being developed.

Shore-based Radar Prototypes: During 1987 a major project to develop a shore-based Ground Wave Radar system was undertaken in cooperation with NorTek Engineering Inc. The aim of the project was to develop a multi-purpose prototype system for vessel traffic monitoring, capable of detecting icebergs/sea ice edges and of performing ocean wave measurements with maximum range to the Canadian territorial limit. Detailed engineering specifications for the prototype were completed during 1987 in conjunction with industrial partners. C-CORE and its partners obtained funding for the construction of the prototype system.

Environmental Measurements

The sea state measurement program concentrated on the development of specifications for a Ground Wave sea-state monitoring radar. Innovative techniques for the interpretation of Ground Wave Radar data to estimate the ocean wave spectrum were developed. These techniques were tested using data acquired with a narrow beam Ground Wave Radar during the Canadian Atlantic Storms Program (CASP) experiment. In addition, techniques for interpreting data from omni-directional radars evolved and

data sets were collected. The latter techniques may be applied to rig or vessel-mounted systems for ocean wave measurements. These investigations were supported through an NSERC strategic grant.

SEABED GEOTECHNICS

The Seabed Geotechnics Group identified three principal thrusts in its five year research plan: marine geophysics, marine geotechnics and marine geology. Most projects in the Group are interdisciplinary and interlinked to enhance the three primary thrusts.

Marine Geophysics

The Co-ASI (Conventional Optimization Acoustic Sub-seabed Interrogator) underwent successful field trials in October, 1987 to assess the performance of the platform under sea-going conditions. Four of the sixteen custom-designed acoustic transmitters were tested. CO-ASI's overall towing stability and the performance of the unique ballasting system exceeded all expectations.

The DAIS (Dynamic Acoustic Intensity Scanning) project focused on the remote determination of fatigue and cracking in offshore structures. Industry and government identified the need for a technique which could reduce costs and improve the efficiency of inspection procedures. The group's project created a new non-destructive testing method called the DAIS. Using an array of three pairs of phase-matched microphones to measure acoustic intensity, the DAIS concept uses a methodology which allows the flow of acoustic energy in the near field of specimen's to be mapped. Under the current work, the DAIS technique is being used to characterize weld beads, machined notches and fatigue cracks in flat steel specimens. The research was supported by CANMET and Brüel & Kjaer Ltd.

Sediment Correlation: Laboratory work on the correlation between geophysical (acoustic) and physical sediment properties using sand-sized sediments was performed this year.

Marine Geotechnics

Iceberg Scour Field Experiment: A major cooperative field project took place in the fall of 1987 involving groups from Canada and Norway. The objective of the program was to characterize the effects on lakebed sediments of scours produced by ice/lakebed interactions in glacial Lake Agassiz, Manitoba. The scours were created and preserved during the Wisconsinan glacial epoch. Examination of these scours is a cost effective method for elucidating the effects of the scour processes on seabed and lakebed soils and for providing data with which to model the scouring process.

Geotechnical measurements using pressuremeters, dilatometers, cone penetrometers, and piezocones were collected. These data were compared to the stratigraphic profile mapped in two trenched scours. Ninety-six

Shelby tube samples were analysed in the laboratory. A comprehensive report of all the findings and data was prepared.

Soil/Structure Interaction: Laboratory studies were conducted to assess and monitor the behaviour of a model-scale seabed-founded structure subjected to intense wave loading. Dynamic soil properties for elastic analysis of the soil/structure interaction were determined. Studies also included the post-grounding behaviour of icebergs subjected to intense wave loading. Funds for this project were provided by NSERC.

Marine Geology

Marine Placers: A major project to study marine placers was initiated this year as part of the marine geology program. Two field investigations were undertaken, one in Port-au-Port Bay, Newfoundland and one on Cook Bank off the northern tip of Vancouver Island, B.C. Genetic and geophysical models were designed to aid in exploration and delineation of both heavy heavy (e.g. gold) and light heavy (e.g. ilmenite) mineral offshore placer deposits. Geological, geophysical and geotechnical databases were compiled for Newfoundland Hydro on the Strait of Belle Isle.

SPECIAL PROJECTS

Measurements on ice motion and *in situ* ice strength collected on the **Labrador Ice Margin Experiment (LIMEX '87)** have been analysed. Preliminary results were presented during the LIMEX meetings in Ottawa in November 1987. Data on floe sizes and ice types have been extracted from the helicopter aerial photographs and will be used to investigate the wave penetration and wave attenuation within the ice cover and to study the ice melt process for the marginal ice zone.

BOARD OF GOVERNORS OF C-CORE

1987 - 1988

Mr. G. Campbell Eaton (Chairman)
Chairman, Seabase Limited

Dr. Jack I. Clark
Director, Centre for Cold Ocean Resources Engineering
Memorial University of Newfoundland

Mr. Wes Abel
Area Manager
Mobil Oil Canada, Ltd.

Dr. G. Ross Peters
Dean of Engineering and Applied Science
Memorial University of Newfoundland
represented by
Dr. T.R. Chari
Acting Dean of Engineering and Applied Science

Dr. Art E. Collin
National Director, Technological and Industrial Strategies
Coopers & Lybrand Consulting Group

Mr. Craig Dobbin
Chairman of the Board
Sealand Helicopters

Mr. Clyde Granter
Deputy Minister
Department of Development & Tourism
Government of Newfoundland and Labrador

Dr. John Harper
Director, Centre for Earth Resources Research
Memorial University of Newfoundland

Mr. Norm F. McIntyre
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Petro Canada Resources

Mr. Roy H.G. Millar
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Department of Fisheries and Oceans

Dr. Ross Pottie
Executive Vice-President
National Research Council Canada

Mr. W. Wayne Thistle
Vice-President (Administration & Finance)
Memorial University of Newfoundland

ASSOCIATES OF C-CORE

1987 - 1988

GOVERNMENT OF CANADA

Energy, Mines and Resources Canada
Fisheries and Oceans Canada
National Research Council Canada
Transport Canada

GOVERNMENT OF NEWFOUNDLAND

Department of Development & Tourism

OIL AND GAS INDUSTRY

Bow Valley Industries Ltd.
Canterra Energy Ltd.
Esso Resources Canada Limited
Gulf Canada Resources Limited
Husky Oil Operations Ltd.
Mobil Oil Canada Ltd.
Petro-Canada Resources
Shell Canada Limited

CONSULTING INDUSTRY

Bechtel Canada Limited
Brüel and Kjaer Canada Ltd.
CANPOLAR Consultants Ltd.
Fenco Newfoundland
GEOTECHnical Resources Limited
Golder Associates
INSTRUMAR Limited
Newfoundland and Labrador Hydro
NewTel Systems Ltd.
NORDCO Limited
NorTek Engineering Inc.
Ocean Explorers Pacific Ltd.
Royal Bank of Canada
Westinghouse Canada Inc.

DEPARTMENT OF THE AUDITOR GENERAL
ST. JOHN'S, NEWFOUNDLAND

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING

FINANCIAL STATEMENTS
31 MARCH 1988

DEPARTMENT OF THE AUDITOR GENERAL
ST. JOHN'S, NEWFOUNDLAND

AUDITOR'S REPORT

The Board of Regents
Memorial University of Newfoundland
St. John's, Newfoundland

I have examined the balance sheet of the Centre for Cold Ocean Resources Engineering as at 31 March 1988 and the statements of revenue, expenditure and surplus (deficit) and changes in financial position for the year then ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests and other procedures as I considered necessary in the circumstances.

In my opinion, these financial statements present fairly the financial position of the Centre as at 31 March 1988 and the results of its operations and the changes in its financial position for the year then ended in accordance with the accounting principles disclosed in Note 2 to the financial statements applied on a basis consistent with that of the preceding year.

J.F. McGrath, C.A.
Auditor General

St. John's, Newfoundland
14 October 1988

STATEMENT 1

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING

BALANCE SHEET

AS AT 31 MARCH 1988

	1988		1987	
ASSETS				
Current assets				
Research trust (Note 3)		$2,047,023		$ 956,484
Accounts receivable				
Operating		311,379		393,695
Total current assets		2,358,402		1,350,179
Fixed assets - at cost				
Bartlett Building (Note 4)		1,080,211		1,038,841
Equipment (Note 5)	1,719,634		1,396,317	
Less: Accumulated depreciation	1,244,212	475,422	1,013,379	382,938
Total fixed assets		1,555,633		1,421,779
Total assets		$3,914,035		$2,771,958

	1988	1987
LIABILITIES AND EQUITY		
Current liabilities		
Accounts payable and accrued liabilities		
Operating	$ 63,427	$ 58,994
Current portion of deferred revenue (Note 8)	76,668	76,667
Interest-free advance from Memorial University of Newfoundland	260,215	338,424
Total current liabilities	400,310	474,085
Long-term liabilities		
Interest-free demand loan from Memorial University of Newfoundland (Note 7)	205,598	230,598
Deferred revenue (Note 8)	-	76,668
Total long-term liabilities	205,598	307,266
Total liabilities	605,908	781,351
Equity		
Equity in research trust	2,047,023	956,484
Equity in building	1,080,211	1,038,841
Surplus (deficit)	180,893	(4,718)
Total equity	3,308,127	1,990,607
Total liabilities and equity	$3,914,035	$2,771,958

See accompanying notes

Signed on behalf of Memorial University of Newfoundland

G.B. Eaton

Chairman of the Board of Governors

Judy Lound-Curtis

Comptroller of Memorial University of Newfoundland

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING

STATEMENT OF REVENUE, EXPENDITURE AND SURPLUS (DEFICIT)

FOR THE YEAR ENDED 31 MARCH 1988

	1988	1987
REVENUE		
Research trust drawdowns	$1,145,553	$ 600,000
Research contracts	1,216,726	986,421
Other	22,058	26,123
Total revenue	2,384,337	1,612,544
EXPENDITURE		
Board of Governors	6,862	6,722
Fellowships and training	23,755	42,378
Ocean Engineering Information Centre	85,172	137,562
Professional fees	2,500	-
Research programs	511,301	374,235
Staff salaries	1,379,392	914,225
Support services	189,744	81,841
Total expenditure	2,198,726	1,556,963
Excess of revenue over expenditure	185,611	55,581
Surplus (deficit) - beginning of year	(4,718)	(60,299)
Surplus (deficit) - end of year	$ 180,893	$ (4,718)

See accompanying notes

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING

STATEMENT OF CHANGES IN FINANCIAL POSITION

FOR THE YEAR ENDED 31 MARCH 1988

	1988	1987
Cash provided by (used in) operating activities		
Industry	$ 602,250	$ 447,500
Government	1,535,000	105,648
Investments	98,842	64,316
	2,236,092	617,464
Transferred to operations	(1,120,553)	(600,000)
	1,115,539	17,464
Cash provided by (used in) financing activities		
Repayment of demand loan	(25,000)	-
Increase in cash during the year	1,090,539	17,464
Cash - beginning of year	956,484	939,020
Cash - end of year	$2,047,023	$ 956,484

See accompanying notes

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING

NOTES TO FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 1988

1. The Centre for Cold Ocean Resources Engineering (C-CORE) is a self-reliant organization of Memorial University of Newfoundland (University) which is the owner of C-CORE's building and equipment and beneficiary of its assets and liabilities. In the event that C-CORE is terminated, facilities and equipment provided or acquired for C-CORE shall remain the absolute property of the University.

As such, these financial statement figures represent a segment of the activities of the University and are included in the audited financial statements of the University for the year ended 31 March 1988.

2. Accounting policies

(a) Basis of accounting

C-CORE follows the accrual basis of accounting except that contributions to C-CORE's research programs are deposited for credit to the C-CORE Research Trust, which is shown on a cash basis (Note 3).

(b) Depreciation

Depreciation is not recorded on the Bartlett Building (Note 4), however depreciation on other fixed assets is calculated on a straight line basis as follows:

Equipment	5 years
Tools and marine equipment	2 years
Computer software and other equipment	1 year

(c) Support-in-kind

Various services have been provided to C-CORE by the University and other agencies, without charge, and have not been included in these financial statements (Note 6).

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING

NOTES TO FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 1988

3. Funds in Research Trust

The Comptroller of the University administers the C-CORE Research Trust on behalf of the Trustee, the Board of Regents of the University.

4. Bartlett Building

In order to properly reflect the entire operations of C-CORE as a separate entity, the Bartlett Building, which is owned by the University but of which C-CORE has exclusive use, has been included in the financial statements at a cost of $1,080,211.

5. Equipment

C-CORE accounts for its equipment in three main categories, as outlined in Note 2.

Category	Acquisitions Less Disposals Since Inception	Accumulated Depreciation	Net Book Value 1988	Net Book Value 1987
Equipment	$1,602,613	$1,127,191	$475,422	$382,938
Tools and marine equipment	91,941	91,941	-	-
Computer software and other equipment	25,080	25,080	-	-
	$1,719,634	$1,244,212	$475,422	$382,938

C-CORE's equipment includes a VAX 785 computer and accessories. The Province of Newfoundland contributed $191,668 towards the cost of this computer and they have secured their contribution by way of a chattel mortgage dated 23 May 1985, which is being forgiven by the Province at a rate of 25% per year.

The Government of Canada also contributed $191,668 towards the cost of this computer. Terms of this contracted contribution require C-CORE to provide for the implementation and provision of a Sea Ice Data Base Service over the period from 22 January 1985 to 31 March 1989.

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING

NOTES TO FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 1988

6. Support-in-kind

Management has estimated the cost of various services provided without charge by the University and other agencies at $765,842 for the year ended 31 March 1988 ($668,700 - 1987). This figure is a representation by management and it has not been audited.

7. Interest-free demand loan

The interest-free demand loan of $205,598 ($230,598 - 1987) represents the cumulative difference to 31 March 1985 between revenues and expenditures that have been advanced by the University to C-CORE. This amount was fixed by an agreement between the University and C-CORE dated 12 February 1987 which is effective from 31 March 1986.

8. Deferred revenue

Government contributions of $383,336 have been recorded as deferred revenue to be amortized to revenue over a five year period ending 31 March 1989 on a straight line basis. Of this amount, $76,667 has been included in revenue for the year ended 31 March 1988.

Publications for 1987

87-1 Woodworth-Lynas, C.M.T., Bass, D.W. and Bobbitt, J. "Inventory of Upslope and Downslope Iceberg Scouring". Environmental Studies Revolving Funds, 039, July 1986, 103p.

87-2 Bass, D.W. and Attwood, D.R. "Iceberg Stability - An Error Analysis". Cold Regions Science and Technology, Vol.13, 1986, pp.49-55.

87-3 Diemand, D., Nixon, W.A. and Lever, J.H. "On the Splitting of Icebergs - Natural and Induced". Proceedings of the Sixth (1987) International Offshore Mechanics and Arctic Engineering (OMAE) Symposium, March 1987, Vol. IV, pp.379-395.

87-4 Shirasawa, K. "Water Stress and Ocean Current Measurement under First-Year Sea Ice in the Canadian Arctic". Journal of Geophysical Research Vol.91, No.C12, Dec.15, 1986, pp.14,305-14,316.

87-5 Walsh, J., Srivastava, S.K. and Dawe, B.J. "Analytic Model Development for the Study of Ground Wave Radars as Remote Sensors in an Ocean Environment". Contract Report, Department of National Defence, Ottawa, Supply and Services Canada No.2SV84-00152, 1986, 175p.

87-6 Hickey, K. "Software Implications for Interpretations of Wave Spectra". Contract Report for Fisheries and Oceans Canada, Dec. 1986. (One of three reports, see 87-38 and 87-39 also.)

87-7 Klein, K. "Evaluation of Two Search Radar Systems for Detection of Ice Masses". Contract Report for Husky/Bow Valley, Jan. 1987; Environmental Studies Research Funds Report No. 091.

87-8 Solomon, S., Guigné, J.Y. "Feasibility Study of the ASI Concept Applied to On-shore Problems". Contract Report for National Research Council, Canada.

87-9 Emory-Moore, M. "Marine Placers: An Overview". National Research Council, Canada / Industrial Research Assistance Program (NRC/IRAP-H) Contract Report, Feb. 1987, 51p.

87-10 Guigné, J.Y. and Solomon, S.M. "Correlation of Acoustic and Geotechnical Properties of Sand Sediments Using Experimental 'Acoustic Sub-seabed Interrogator' Technology". Contract Report, Atlantic Geoscience Centre.

87-11 Nadreau, J.P. "Survey of Physical and Mechanical Properties of Icebergs". National Research Council Canada, Workshop on Extreme Ice Features, Banff, AB, Nov. 3-5, 1986, Technical Memorandum 141, NRCC 28003, June 1987.

87-12 to 87-17 In: "Ice Scour and Seabed Engineering, Proceedings of a Workshop on Ice Scour Research". C.F.M. Lewis, D.R. Parrott, P.G. Simpkin and J.T. Buckley, eds., Environmental Studies Revolving Funds, Report No.049, Dec. 1986.

87-12 Barrie, J.V. "Sediment Transport and Iceberg Scour Preservation and Degradation, Eastern Canadian Shelf". p.63.

87-13 Woodworth-Lynas, C.M.T., Christian, D., Seidel, M. and Day, T. "Relict Ice Scours on King William Island, N.W.T.". pp.64-72.

87-14 Barrie, J.V., Collins, W.T. and Parrott, D.R. "Grand Banks Pits: Description and Postulated Origin". pp.73-77.

87-15 Barrie, J.V. and Barnes, P.W. "Ice and Ice-Scour Processes: Summary and Discussion". pp.82-84.

87-16 Bass, D.W. and Woodworth-Lynas, C.M.T. "Iceberg Crater Chains and Scour Up and Downslope". pp.122-128.

87-17 Woodworth-Lynas, C.M.T. and Simms, A. "Iceberg Grounding Study, Labrador Well-site Observations". pp.269-283.

87-18 Parsons, B.L., Snellen, J.B. and Hill, B. "Preliminary Measurements of Terminal Crack Velocity in Ice". Cold Regions Science and Technology, 13 (1987) pp.233-238.

87-19 Collins, W.T., Parrott, D.R., Barrie, J.V. and Imber, B. "Tools and Techniques for Manned Submersible Studies of Sediment Transport and Ice Scour on the Eastern Canadian Continental Shelf". Proceedings of Offshore Technology Conference, Vol.3, OTC No.5517, Houston, TX, April 27-30, 1987, pp.289-294.

87-20 Nadreau, J.P. "NRC/IMD Expertise Project". DSS Contract Report 31234-6-2903/01-OLZ, May 1987.

87-21 Howell, R., Srivastava, S.K. and Walsh, J. "Estimation of Sea Surface Parameters Using an HF Ground Wave Radar and Comparison with Buoy Estimates". Presented at Canadian Atlantic Storms Program (CASP) Workshop, Bedford Institute of Oceanography, Halifax, NS, Dec. 1986. Memorial University of Newfoundland, Faculty of Engineering and Applied Science, Internal Report, 1987.

87-22 Walsh, J., and Srivastava, S.K. "Rough Surface Propagation and Scatter 1. General Formulation and Solution for Periodic Surfaces". Radio Science, Vol.22, No.2, 1987, pp.193-208.

87-23 Walsh, J. and Donnelly, R. "A General Theory of the Interaction of Electromagnetic Waves with Isotropic Horizontally Layered Media" (summary). Radio Science, Vol.22, No.4, 1987, pp.545-548.

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